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Present Approaches to Toxicity Testing A Perspective

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16. ABSTRACT

Interest in aquatic toxicity tests is increasing as more emphasis is placed on control of highly toxic pollutants. While this interest offers an opportunity to increase the use of aquatic toxicity tests, there is a responsibility to recognize their limitations. Aquatic toxicology may well be developed into a recognized professional field along with medicine, pharmacology and others.

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Present Approaches to Toxicity Testing—A Perspective

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It is a real pleasure to see that so many industrial people are actively working in aquatic toxicology. Formerly, papers were presented mostly by participants from public agencies since they were the ones doing aquatic testing at that time. Now many people utilize such tests to assess hazards to aquatic life from many forms of pollutants.

In publishing the proceedings of this first ASTM symposium on aquatic toxicology, we all need to remember some things that will help us develop this into an accepted profession rather than a specialty field the way aquatic bioanalysts are now viewed by others. Let us focus our attention on some of the problems that plague our "profession."

In the last five to ten years, bioassays and toxicity tests have come into their own, and many people are now turning to them to solve problems, some of which I fear are not solvable. We must make sure that people do recognize the potential uses of aquatic toxicology, but, at the same time, it behooves all persons working in this field to be sure that people do not expect more than we can deliver. I see danger on the horizon if we oversell our product. We must not let aquatic toxicology become a panacea and then lose its usefulness.

Every time toxicity raises its ugly head these days, toxicity tests are hauled out of the closet to solve the problem. Depending on how we handle the situation, we could be on the brink of disaster or success.

Time is flying, so we must take every opportunity to get about the business that is before us, that i., to set bioassays and toxicity tests in their proper perspective and to teach many people (most of them untrained technicians) how to employ these tests and how to get the most for the cost.

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We must determine which way we are going—toward disaster or success. I hope this publication will be the first of many where we set our course of action and decide what way we will go.

We must anticipate our problems clearly, with the understanding that bioassays and toxicity tests have a variety of purposes and provide a variety of answers. Each of us must recognize what our objectives are and realize that "the best" approach depends on the purpose of the test. Let us look at some of the purposes of aquatic tests and examine what we are doing with them. Probably the oldest and most classic use of bioassays is to determine the strength of a substance, such as enzyme activity or potency of drugs. This is a true bioassay and not a toxicity test because measuring the strength or potency is the objective. Even this oldest use is relatively new in aquatic biology. A recent experience emphasizes how young aquatic toxicology is. Last week, I was going through some old record books from 1964 and on one page, written in very large handwriting with exclamation marks after it, was, "THE FISH SPAWNED TODAY!!" I believe that was the first time that fish had spawned in a toxicity test—yet that was less than twelve years ago. So, while the use of bioassays to determine potency may be considerably older, your profession and mine is really in its infancy.

We often use toxicity tests to predict effects, and then our approach will be quite different. When determining potency, the test organism—bacteria, invertebrates, or fish—matters little as long as the response is sensitive enough. However, when one wants to predict effect, there are other important considerations, as in pesticide registration, where you want to anticipate the pesticide's impact on nontarget species. Certainly, the selection of alternative waste treatment methods to find one that gives the best effluent or the identification of the waste stream producing the most toxicity are ways we use bioassays to predict effects. The recently passed toxic substances legislation will bring about an unheralded demand for tests to predict environmental effects before they have happened. I hope and expect the premarket testing of the many chemicals subject to this legal and mandatory scrutiny will include aquatic toxicity testing.

We are recognizing more and more problem chemicals in the environment that are not directly toxic but instead bioaccumulate, producing undesirable residues in the body. Certainly, toxicity tests designed to measure this end point must be different than those to measure direct toxicity. We also can see now that many of the problem contaminants in the environment are persistent ones. However, we are in the very infancy of knowing how to test persistence of materials effectively and realistically, and a method to measure persistence is an important and current need in our field.

Whether or not to develop a new product is an increasingly important use of these tests. For a long time, the drug industry has used toxicity tests to determine the suitability of a chemical for further product development. Now, many industries are using aquatic testing during product development

to decide whether or not a new product will result in environmental problems. I know of several instances where promising chemicals were rejected because the aquatic toxicity data predicted environmental problems. Finally, water quality standards or criteria intended to be "no-effect" concentrations in the environment constitute yet another need for toxicity tests.

Some of you may wonder why I am taking time to remind you of these various purposes. If so, you are just like the man sitting in church on Sunday who thinks the preacher is talking to the "man behind him." I frequently see many of us getting confused and disagreeing with each other over what kinds of methods or tests to employ because we are thinking about different objectives. Undoubtedly, we need a whole battery of tests and not just one magic method. I think we must forget about the "most representative species" or "the" right-sized test animal. First, look at the purpose of the test, then worry about what species to use.

The chronic or life-cycle test—whether it be on fish, invertebrates, or other organisms—is and must be the mainstay of our profession for some time to come. Newcomers to our profession may not appreciate what we are able to do today because we have already produced a chronic toxicity data base that we use to judge the many shortcut methods and quick procedures now proposed. In 1967, when we began our work at the laboratory in Duluth, many investigators were interested in looking at shortcut methods and faster ways of testing. But we had no way to judge whether a physiological or behaviorial response was a sensitive and therefore useful test until we had chronic data to use as a guide. All sorts of methods—physiological, biochemical, and otherwise—were being proposed as the way to solve the problems, but you could not tell if they were usable or not. Today, we are not in that situation because a great amount of resources have been expended to develop chronic test data. The Duluth laboratory alone has probably spent ten million dollars doing chronic bioassays in order to build a data base that enables us to judge the validity and use of short-term tests.

I urge all of you, as I do our staff in Duluth, to stay with the chronic tests as our guideposts—this will keep us on course. If we leave chronic tests, we will go astray. I point up the prominent role that the chronic mouse test still plays in medical toxicology, a field immensely older than our own. It is still the mainstay used to judge physiological responses. However, even though chronic tests are indispensable, they are not the only tests we need to do. It is my philosophy that we should advance on many fronts simultaneously. There is little value in having full knowledge of a few chemicals yet knowing nothing about the rest. We are not being practical if we have sophisticated tests for one organism but cannot test many others.

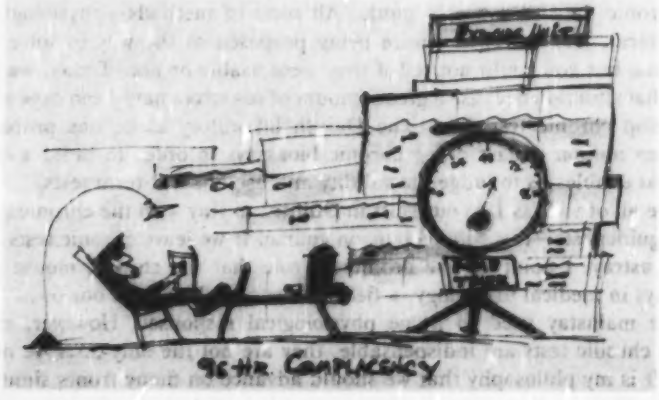
This brings me to my opinion that our bioassay and toxicity test methods are far ahead of our ability to apply the results. We well know how to get water from Point A to Point B, and anybody who has done flow-through testing knows how to put an air trap in the line to get rid of air bubbles.

Air bubbles are not our problem any more. Our problem is what to do with the data after we get them and how to apply them to predict occurrences in the real world. This is where I think we should concentrate in the coming years. We must deemphasize the use of gadgets and instead channel more effort to thinking about what it is that we have produced and how it can be useful. That thinking effort will be far more productive than conceiving another gadget.

In spite of our symptoms, I think that aquatic toxicologists have an opportunity before them today that will not last long and is not likely to come again soon. It is the opportunity to become a true and respected profession if we act responsibly and responsively. Perhaps we should establish the Aquatic Toxicologist Association and model it after the American Medical Association policy of saying something good or else nothing about our colleagues.

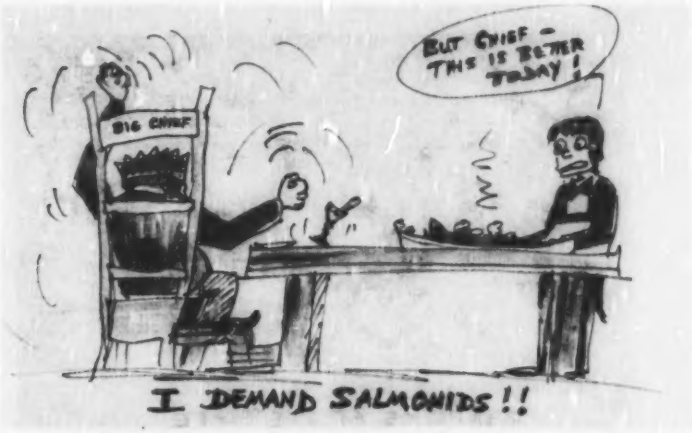
Before we turn to a menu of fine scientific papers, let me take this opportunity to thank Glenn Christensen of my staff for his professional illustrations of my thoughts.

Now I would like to illustrate a few of our problems. So you're going to run a bioassay!

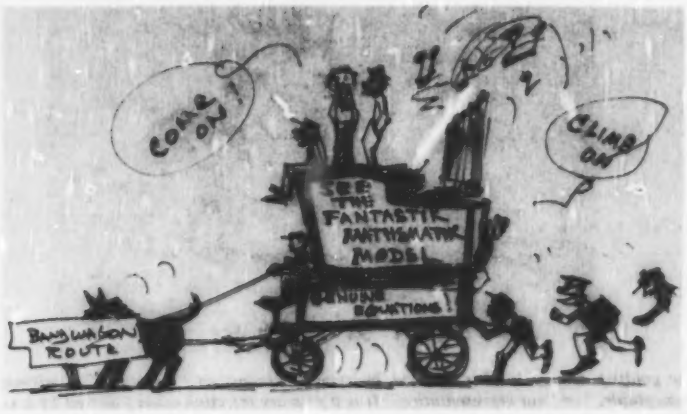


Beware of the 96-h complacency. You can recognize it because it is "standard," "convenient," "representative," and "long enough."

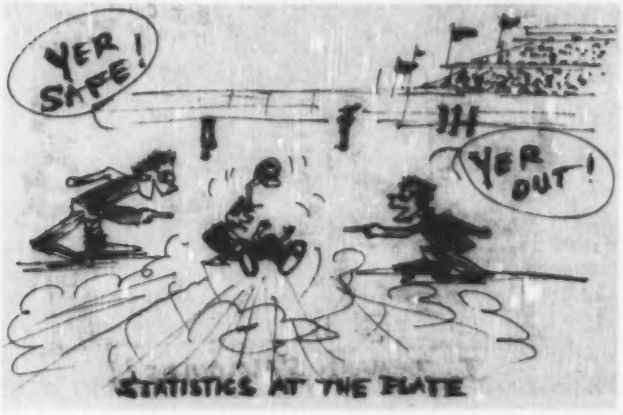
The goldfish allergy is characterized by such symptoms as "unnatural," "misleading," "unacceptable," or "not representative." It is a primary infection often followed by a secondary infection called "salmonid cuisine."



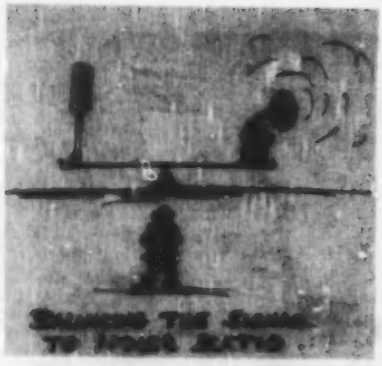
This is easily recognized by terms such as "best bioassay species," "the most sensitive test," and "most representative."



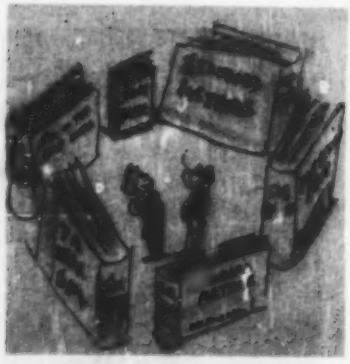
The unerring "model bandwagon" is saturated with assumptions too expensive to verify.



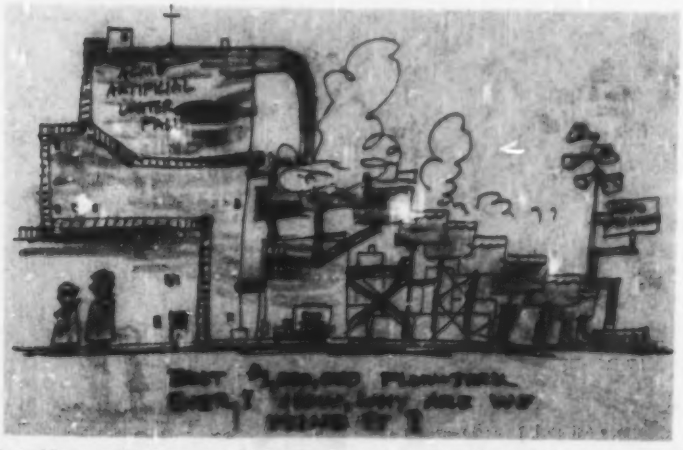
The statistical out can be recognized by more pages devoted to complex formulas than for data or by simple sentences like, "While statistically the same, the difference is a real effect due to enzyme deficiency."



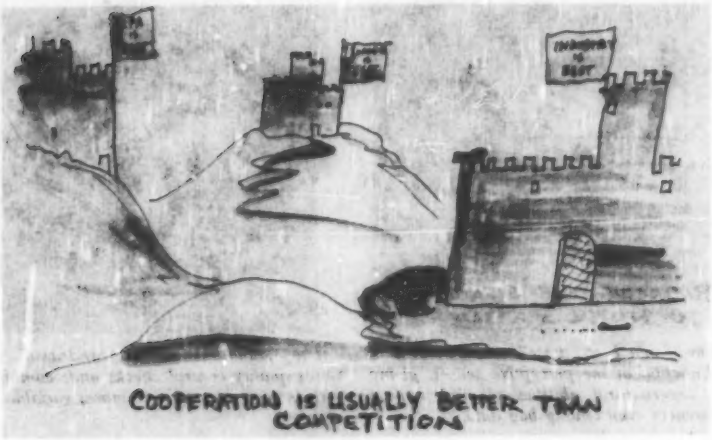
The "signal to noise" imbalance is a malfunction of the perceptive senses, giving one supernatural abilities to find minute differences even among bad data.



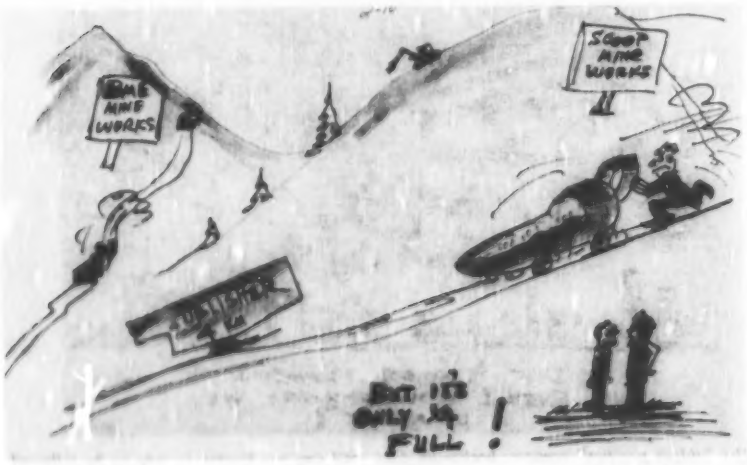
The "standard method withdrawal" obviates quality control checks and, combined with infrequent testing, removes variability.



The "gidget pacifier" removes bother by data, and one publication is sure to be followed by yet another on a better gidget.



Professional jealousy is best identified by results "too preliminary to release."



"Scoop paranoia" is best represented by a simple equation reading, "One 96-h test equals one publication."

The "microcosm cure" is a better approach because one has a community, even if the makeup of the community is Anabena, Daphnia magna, *and* Salvelinus namaycush.

The ivory tower retreat occurs "where usefulness is a handicap, and practicality is a terminal disease."

And alas, "more research is needed," forming the bioanalysts' unemployment compensation security.